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Technical Cooperation on Verification and its role in Trust Building

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by

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Technical Cooperation, Test Ban Treaties, Arms Control Verification, Seismic Verification, Hydroacoustic Verification, Lab to Lab Cooperation, Joint Verification Experiment (JVE), NRDC-Soviet Academy Joint Verification Experiment.

IV. INTRODUCTION

The purpose of this paper is twofold. First, it will demonstrate how technical cooperation on verification contributed to the softening of tensions and the improvement of trust between the United States and the Soviet Union. Because the scope of this endeavor is too broad to be adequately considered in the length of this work, the primary focus will be on the private and public partnerships on seismic and hydroacoustic test ban treaty verification that were forged between Soviet and American scientists from 1986-1988. In order to orient the analysis within the political-scientific landscape of the time, the discussion begins with a brief description of the arms control landscape in the early 1980s, including both the stances of the Reagan and Gorbachev administrations vis a vis nuclear test ban verification. The section concludes with an analysis of the two primary US-USSR collaborative projects in this key sphere – the test ban verification project conducted by the National Resources Defense Council (NRDC) and Soviet Academy of Sciences (SAS) and the Joint Verification Experiment (JVE) between the US and Soviet National Laboratories.

Using these case studies, it will outline the three core ways in which technical cooperation was able, in the face of significant odds, improve the trust between the two Cold War adversaries, both at the interpersonal and governmental levels. First, the operational experience of working together to overcome technical hurdles in the planning and execution of the experiments built mutual respect and improved trust between those directly involved. This was especially true for the inter-lab Joint Verification Experiment. As many of the participating scientists would eventually remark in later works on the effort, their unique position as the guardians of each

nation's nuclear deterrent and the immense responsibility involved in this work, had led the weapon laboratories of both sides to convergently evolve a set of similar values and world views, which were only made clear to the other through the interactions brought about by cooperation. These relationships and the trust they relied on would later come to undergird the unprecedented level of lab-to-lab and extra-lab work on nuclear issues that lasted through the 1990s. Second, the demonstrative aspect of both cooperative verification experiments – the actual *act* of carrying them out – served as an effective proof-of-concept for both the Reagan and Gorbachev administrations, pushing the concept of on-site verification from the negotiation table to the actual test site and helping to convince each government of the other's commitment to the verifiable cessation of nuclear testing. The work of the NRDC and Soviet Academies, in this regard, was a key precursor to the JVE agreement. Motivated private individuals, accomplishing in the arms control arena what their governments either could not, or were not willing to try, effectively both increased the political stakes for the Reagan administration at a time when domestic anti-nuclear sentiment was at a boiling point and lowered the barrier to an intergovernmental agreement by proving that such cooperation was, indeed, possible. Finally, the savvy utilization of domestic and international press in both the NRDC-USSR and JVE had a positive effect on public perceptions of the verifiability of the ban treaties and, by extension, the trustworthiness of their historic adversaries by allowing for a humanizing lens into the secret worlds of the US and USSR nuclear weapons complexes and the people running them, and by showcasing that cooperation was not only possible, but in the interest of both nations. This had an effect not only on the domestic discourse in each country but, as will be discussed later, on key players in philanthropic organizations underwriting many of the private US-Soviet partnerships in nuclear security and arms control. The confluence of these three means of influence -- shared operational experience, demonstrative

performance, and public messaging – had the cumulative effect of improving relationships and perceptions at the inter-scientist, intergovernmental, and public levels. This improved trust enabled arms control advocates to effectively utilize the policy window opened in the mid-1980s by Reagan and Gorbachev to end the political stalemate on test ban treaty verification. The section ends by tracing how the relationships built between scientists from 1986-1988 laid the foundations for future cooperation in the technical arms control sphere – the NRDC-USSR Black Sea experiments and the 1990s Laboratory to Laboratory projects, demonstrating how each round of transnational contact between scientists strengthened the case for future collaboration and improved trust between the parties involved.

One should not conclude based on this study, however, that once doorways to cooperation on arms control issues are opened, they cannot be closed. The second goal of this research is to extrapolate how windows of opportunity for technical cooperation in sensitive areas are created and destroyed though a careful examination of these case studies and to access the possibilities for future cooperation. In service of this goal, the discussion begins with an overview of which factors – in the minds of the participants – enabled the success of the joint verification initiatives of the 1980s; namely, political leadership willing to take a risk, the creativity of individual scientists, and the actions of private individuals willing to pressure their governments through their own initiatives. Next, it will provide historical context for the changing conditions that eventually brought the successful lab-to-lab cooperation born of the JVE experience to end. Using insights derived from these two crucial time frames—the rapid beginning and slow decline of cooperation between national laboratories and on nuclear issues – this section proposes a spectrum model for evaluating the structural-political conditions necessary for windows of opportunity to open.

A key finding is that technical cooperation in sensitive areas between states cannot increase in perpetuity. The natural tensions between secrecy and security concerns and the level of access and transparency required for true peer level technical cooperation (as opposed to patronage, which can engender negative feelings between parties based on power asymmetries) will eventually prompt factions within the state to intercede and push to return the system to a prior, preferred state. Political will, as will be demonstrated in this case, though necessary for cooperation to take place, is insufficient in the face of such structural obstacles. Finally, using this model, this research will examine the current state of US and Russian research complexes, and attempt to draw conclusions about the possibility of future cooperative windows.

In conclusion, this work aims to demonstrate both how technical cooperation on arms control verification can contribute to improved relations between parties and the conditions necessary for such cooperation to occur. Drawing on the lessons learned from the successes, and failures, of past projects, this paper shows how technical cooperation offers a potential path forward for the United States and Russian administrations; a low-cost way to rebuild trust and potentially pave the way for future arms reductions at a time when both trust, and extant arms control agreements are in increasingly short supply.

V. CHAPTER ONE: THE POLITICAL LANDSCAPE OF THE EARLY 1980S - UNCONDUCIVE TO COLLABORATION

As the world entered into a new decade and the brief flicker of detente between the United States and the Soviet Union drew to a close, the political landscape for movement on arms control issues, let alone direct collaboration between nuclear weapons scientists, appeared bleak. The Soviet invasion of Afghanistan in 1979 and the election of Ronald Reagan in 1980, who had run on a specifically, if not virulently, anti-detente platform, set the stage for the escalation of tensions between the two superpowers in the early years of the decade. The situation reached a peak in 1983, when Reagan announced his Strategic Defense Initiative. The project was a longshot, given the technical capabilities of the time. However, the idea of an insurmountable space-based shield – a capability which would immediately undermine the prevailing logic of strategic stability and render impotent the strategic nuclear forces which, in the eyes of the Soviet Union, guaranteed their survival – was of grave concern to Soviet leadership. [1] The sharpening of tensions was more than military in nature. In the same year, Reagan delivered his famous "Evil Empire" speech to the 41st Annual Convention of the American Association of Evangelicals – reframing the Cold War as a broader existential struggle between "right and wrong and good and evil." [2] The speech demonstrated to the Soviet Union that the new administration had no allegiance to the strategic logic of the past and was content to escalate the ideological and military

[1] Podvig, Pavel. "Did Star Wars Help End the Cold War? Soviet Response to the SDI Program." *Science and Global Security.* Vol. 25, Issue 1. February 2017.
[2] Reagan, Ronald. "Address to the National Association of Evangelicals ("Evil Empire Speech")". *Voices of Democracy: The U.S. Oratory Project*. University of Maryland, College Park. March 8, 1983.

conflict from the pages of clandestine influence publications and battlegrounds of unfortunate proxy countries to a much more public forum. [3]

However, by the end of 1983, political winds had slowly begun to shift in the direction of arms control advocates. A series of events, some of which nearly brought the United Stated and the Soviet Union to the brink of accidental nuclear exchange, served to change Reagan's mind on the topic of nuclear weapons. First, on September 1st of that year, a Soviet Su-15 jet fired two air-to-air missiles at what had been mistakenly identified as an American reconnaissance plane, but which, in reality, turned out to be a Korean airliner which had wandered off its expected route. Despite American intelligence quickly determining the deaths to have occurred in error, Reagan used the downing of Korean Air Flight 007 as an opportunity to lambast the Soviet Union in the press. [4] Likely unbeknownst to the Reagan, Premier Andropov had already been on high alert since the summer of 1983, when he had refocused defense planning on the real possibility of nuclear war following the proposed deployment of US Pershing II missiles in Europe and had placed KGB agents on alert for any intelligence that could indicate preparations for a strike. [5] Following the incident he issued his among his strongest condemnations of the United States to that date, describing the Reagan administration's trajectory " a militarist course that represents a serious threat to peace...if anyone had any illusion about the possibility of an evolution for the better in the policy of the present

[3] Goodnight, Thomas G. "Ronald Reagan's re-formulation of the rhetoric of war: Analysis of the "zero option," "evil empire," and "Star Wars" addresses." *Quarterly Journal of Speech*. Vol. 72, Issue 4. 1986.
[4] Hoffman, David. "1983: A Turning Point in the Cold War." *Security Index*. No. 1 (81), Vol. 3. Pp. 141.
[5] These included any perceived increase in US intelligence efforts or increase in the price of blood donations (apparently unaware that blood is usually donated without compensation). Ibid. pp. 139-140.

administration, recent events had dispelled them completely." [6] Second, less than a month later on September 26, 1983, Soviet early-warning station Serpukhov-15 would register an alarm – first for the launch of a single missile and then for a barrage. With no time to perform the operations necessary to validate the system, Department of Combat Algorithms Deputy Chief Stanislav Petrov chose to relay the message that it was false alarm based on his instinct and experience, without proof. His judgement was correct, but for 10 minutes in 1983, the responsibility for initiating the series of events which would likely have resulted in a retaliatory strike rested in the hands of one man. [7] Finally, and possibly most significantly for Reagan himself, the ABC television special "The Day After" depicted clearly the potential consequences of a Soviet nuclear attack on an average American town. Writing in his diary about the movie's impact on him, Reagan remarked "It is very effective and left me greatly depressed … My own reaction: we have to do all we can to have a deterrent and to see that there is never a nuclear war." [8] By December, cabinet officials were noting the American president's strong shift in stance on nuclear weapons. This sentiment was made public during a televised speech on January 16, 1984. In stark contrast to his early rhetoric, Reagan this time appealed for cooperation, particularly in the arms control arena, proposing a new policy of "a credible deterrence, peaceful competition, and constructive cooperation." [9]

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[6] Ibid. pp. 139-140.

[7] Andropov's health, already poor, would take a drastic turn for the worse in the days after the incident. Ibid. pp 142-143.

[8] Reagan, Ronald. *The Reagan Presidential Diary*. Oct 10, 1983, The Reagan Foundation, White House Diaries.

[9] Reagan, Ronald. "Address to the Nation and Other Countries on United States-Soviet Relations." January 16, 1984. *Reagan Presidential Library*.

This favorable shift towards arms control and de-escalation of tension was aided by the ascendance to power of a new premier in 1985 – Mikhail Gorbachev. Premier Gorbachev's commitment to *glasnost*, loosening domestic control and improving international relations between the West and the Soviet Union, and open mind would later play a key role in the organization of the first technical cooperative project on test ban verification between US and Soviet scientists. [10] In the later years of his career, this commitment to openness would come to explicitly encompass technical cooperation, as Gorbachev strove to diversify the Soviet economy, moving away from a singular defense orientation and focusing on civil production.

On November 21, 1885, Gorbachev and Reagan made a historic joint statement, affirming their commitment to the principle that "nuclear war cannot be won and must never be fought" and committing themselves to moving forward with negotiations on arms control issues. [11] A clear distinction should, however, be drawn between committing to negotiations and the concrete result of the negotiations process. Though conditions were indeed improving by 1985, technical cooperation was far from a preordained outcome, nor was political will alone sufficient to ensure its success. Despite Reagan's personal feelings and rhetorical commitment to progress in arms control, many in his administration, particularly within the echelons of the Department of Defense, remained staunchly opposed to any constraint on American capabilities in certain spheres. One of the most contentious areas was the nuclear test ban movement – with two treaties still unratified and the prospect of a third looming – a lack of accurate and reliable verification measures became central

[10] Bath, Kai-Henrick "Catalysts of Change: Scientists as Transnational Arms Control Advocates in the 1980s" *OSIRIS.* 2006: 21. pg. 182-206.
[11] Joint Soviet-United States Statement on the Summit Meeting in Geneva. November 21, 1985. Reagan Presidential Library.

to the administration's argument in its refusal to join the Soviet Union in a voluntary moratorium and in dragging its feet on the negotiations of a comprehensive test ban (CBT).

VI. CHAPTER TWO: ARMS CONTROL'S THORNIEST PROBLEM - VERIFICATION

By the time the Reagan administration began its attempts to bring the Soviet Union to the negotiating table for effective verification measures for the Threshold and Peaceful Nuclear Explosions Test Ban Treaties in 1983, both had been languishing unratified in the American Congress for nearly a decade. [12] The Threshold Test Ban Treaty (TTBT), which set a 150 Kiloton limit of the yield of underground nuclear tests, was signed between the United States and Soviet Union in July 1974. In May of 1976, despite the lack of progress on ratification on the TTBT, the Peaceful Nuclear Explosions Treaty (PNET), which similarly capped the yield of peaceful nuclear detonations, was added. In order to prevent the two treaties from undermining one another – that is to say, to prevent either party from continuing to test above the set 150 Kiloton threshold by simply claiming the test to be of whichever type was not yet enforced, peaceful or defense related, they were linked together as a set. One could not be implemented without the other. Of the three extant ban treaties, the United States had only formally entered into one – the Limited Test Ban Treaty (LTBT) or Moscow Treaty, prohibiting nuclear tests in the atmosphere, underwater, and in outer space. The primary barrier to the ratification of the TTBT and PNET, as well as to the implementation of the LTBT, was the problem of verifying compliance. [13] The most difficult challenge presented on this

[12] Chronology of Historical Events and Negotiations Leading to Joint Verification Experiment." No Date. NV0320159. NNSA/NSO Nuclear Testing Archive. Nevada Nuclear Security Site, Las Vegas, NV. Accessed: March 2020.
[13] Bureau of Arms Control Verification, and Compliance. "Treaty Banning Nuclear Weapons in the Atmosphere, in Outer Space and Under Water" *US Department of State.*

front was the problem of underground nuclear testing , the detectable signals from which scientists at the time predicted could be suppressed or muffled in the test cavity to level below that of normal background frequencies. [14]

Through the first half of the 1980's, factions within the Reagan administration remained firmly entrenched in their resolve to continue with the American nuclear testing programs while the government as a whole waited for an opportune political moment to move forward with treaty commitments. The development of verification measures emerged as a central issue in the American position on test ban treaties. Reagan himself became famously fond of the Russian expression "доверяй, но проверяй" or "trust but verify" to summarize his position on arms control issues. As outlined in National Security Decision Directive (NSDD) Number 51 in late 1982, "US Nuclear Testing Limitations Policy," Reagan affirmed that a Comprehensive Test Ban "remains a long term objective" but that "our [American] security requires that we not agree to an unverifiable treaty," concluding that efforts toward the ratification of the TTBT and PNET should not proceed. [15] In a follow-on decision aimed at supporting NSDD 51, plans were laid for technical negotiations with the Soviet Union on verification measures. [16] Two weeks later, a National Security Council Arms Control Verification Committee was established. [17] On December 2, 1983, the General Advisory Committee on Arms Control and Disarmament submitted a classified report "A Quarter Century of Soviet

[14] Evernden, J. E., Archambeau, C. B., and Cranswick E. "An Evaluation of Seismic decoupling and underground nuclear test monitoring using high-frequency seismic data." *Reviews of Geophysics*. Vol. 24, Issue 2. May 1986.
[15] U.S. Nuclear Testing Limitations Policy. NSDD 51 (August 10, 1982). Reagan Presidential Library.
[16] Basis for Negotiation of Nuclear Test Verification Measures. NSDD 63 (October 28, 1982). Reagan Presidential Library.
[17] Establishment of National Security Council Arm Control Verification Committee. NSDD 65 (November 10, 1982). Reagan Presidential Library.

Compliance Practices under Arms Control Commitments: 1958-1983" to President Reagan. The accompanying unclassified congressional summary, reprinted in the Bulletin of Atomic Scientists the same year, revealed numerous allegations levied against the Soviet Union in the sphere of nuclear testing. [18] Additionally, it concluded "the near total reliance [of the United States] on secret diplomacy in seeking to restore Soviet compliance has been largely ineffective." [19] According to documents obtained from the Nevada National Security Site (NNSS) archives, in 1983 "on several occasions the United States [sought] unsuccessfully to engage the Soviet Union in negotiation on effective verification measures for the TTBT and PNET" A few months later, the Reagan administration first proposed on-site yield measurements of American and Soviet nuclear devices. [20] It was not until the following year, when Reagan invited Soviet representatives to the Nevada Test Site (NTS) to measure a nuclear test and proposed future discussions between United States and Soviet technical experts to discuss respective views on verification, that momentum within the national security bureaucracy toward productive work on enforceable verification measures began to build. [21]

Throughout most of its history, the Soviet Union was a consistent voice for the limitation and cessation of nuclear testing – it would make its first proposal for a ban on testing as early as May of 1955. Through the beginning of the 1980s, the

[18] General Advisory Committee Report Excerpts," *The Bulletin of Atomic Scientists.* Jan. 1983. pp 33.
[19] Ibid. pp. 34.
[20] Chronology of Historical Events and Negotiations Leading to Joint Verification Experiment." No Date. NV0320159. NNSA/NSO Nuclear Testing Archive. Nevada Nuclear Security Site, Las Vegas, NV. Accessed: March 2020.
[21] On August 23, 2010, almost 50 years after the last US nuclear test, the Nevada Test Site was renamed the Nevada Nuclear Security Site. Here, the historical name is used throughout. For more information on the name transition, see https://www.nti.org/gsn/article/nevada-test-site-renamed/

Soviet Union firmly supported the implementation of the 1974 Threshold Test Ban Treaty, even without additional verification measures, despite American concerns on the matter. Rather than viewing the development of verification protocols as a precursor to implementation, Gorbachev continued to reasonably insist that both nations concede to abide by the treaty before such talks could begin. [22] Significant issues, however, remained. [23] Extreme American distrust over Soviet compliance was a core issue during this time. [24] Gorbachev's voluntary testing moratorium, which he unilaterally undertook in 1985, was frequently dismissed by American analysts as propagandistic in nature, aimed primarily at elevating the moral capital of the Soviet Union in the eyes of the international community and diminishing that of the United States. Additionally, Soviet policy at the time on arms control on-site verification had not changed for 30 years. [25] The Soviet norm at the time was to maintain such strict secrecy that no Soviet personnel, save the operationally necessary minimum, were allowed to be present – let a alone the question of foreign attendance. [26] Thus, though the tide was beginning to turn by 1985, deep divides between the two countries remained. The United States both wanted to leave open the option for testing and had deep misgivings about the motivations behind the

[22] Gordon, Michael R. "Reagan, in a Letter to Gorbachev, asks Technical Talks on A-Tests." *New York Times.* December 25, 1985.

[23] Chronology of Historical Events and Negotiations Leading to Joint Verification Experiment." No Date. NV0320159. NNSA/NSO Nuclear Testing Archive. Nevada Nuclear Security Site, Las Vegas, NV. Accessed: March 2020.

[24] American misgivings over Soviet was so bad that, as one contemporary Russian publication remarked, "all" Western journal articles received by Soviet libraries at the time dedicated themselves to the question of noncompliance, and frequently asked if data was being cut out of Soviet publications, including those supporting the absence of violations, by censors. Амрамина, А. А. and Пилипенко В. А pp 6.

[25] Bahn, pp. 183.

[26] Voloshin, Nikolai P. "Scientific and Technical Cooperation between the Nuclear Weapons Institutes of the USSR and USE for the Joint Verification Experiment." Doomed to Cooperate Volume I, edited by Siegfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. Pp. 101.

Soviet test moratorium, and the Soviet Union held firm in its opposition to on-site inspection.

In the end, both sides would compromise. On December 25, 1985, in response to his repeated urges for the United States to join the Soviet Union's testing moratorium, President Reagan wrote Mikhail Gorbachev, once again declining the proposal but inviting Soviet scientists to technical talks on improving verification methods for nuclear testing. [27] By this time, Premier Gorbachev had begun to soften the Soviet stance on on-site inspections and negotiations on an Intermediate-Range Nuclear Forces (INF) Treaty were moving forward in earnest. [28] Though the INF Treaty signed on December 8, 1987 was the first US-Soviet bilateral arms control treaty to contain on-site verification protocols, participants in the NRDC-USSR verification project and JVE would actually become the first individuals, private and government, allowed on each other's territory for the purposes of verifying compliance with an arm's control treaty. To these scientists, therefore, fell the extreme challenge of figuring out just how to make reciprocal verification visits work, both bureaucratically within their vastly different legal systems, and technically. [29]

[27] Gordon, Michael R. "Reagan, in a Letter to Gorbachev, asks Technical Talks on A-Tests." *New York Times.* December 25, 1985.
[28] "The Intermediate Range Nuclear Forces (INF) Treaty at a Glance" *Arms Control Association Briefs.* August 2019.
[29] Robinson, C. Paul. "The Joint Verification Experiment and Nuclear Testing Talks: Important Precursors to the US-Russian Lab-to-Lab Programs." *Doomed to Cooperate Volume I,* edited by Siegfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. Pp. 90. The preparations mentioned in Ambassador Robison's account included the divisions of preparatory groups into policy and technical, to insulate the latter from thornier political discussion, and eventually resulted in an exhaustive 3-inch-thick agreement.

V. CHAPTER THREE: A CASE STUDY IN THE ROLE OF TECHNICAL COOPERATION IN TRUST BUILDING: EXPERIMENTS IN JOINT VERIFICATION

A Foundation is Laid: the NRDC Soviet Academy Project

As the debate over test ban verification debate was being waged between Washington and Moscow in 1980, the National Resources Defense Council (NRDC), founded in 1970 by a group of attorneys working at the helm of the United States environmental legal movement, enjoyed significant prestige in the sphere of public health and environmental advocacy; Dr. Thomas Cochran, a senior scientist in the NRDC's nuclear program, had been working in the civilian nuclear power sector in the early 1980s. As the Reagan administration's stance on arms control issues became increasingly hawkish through the early years of the decade, he made the unconventional decision to pivot from the nuclear energy sector to weapons issues. Cochran quickly recognized, however, that "no one would give us the time of day [as an environmental organization]." [30] Actual arms control – that is to say the negotiation and implementation of agreements as opposed to arms control policy advocacy – which at the time remained traditionally the purview of governmental organizations rather than NGOs, was for the NRDC, relatively unexplored waters. In order to increase their credibility in the arms controls sphere, Cochran recognized that would need to gain experience. He began researching and writing a series of publications, extrapolating information on nuclear testing based on open sources –

[30] Cochran, Thomas. Personal interview. 01 April 2020.

The Nuclear Weapons Databooks. [31] [32] Politically, in the face of a Department of Defense (DOD) firmly entrenched in its views on the necessity of nuclear testing, the work would have little impact at the time of publication. [33] His "breakthrough" moment came when the first installment of the five part series received a glowing review from McGeorge Bundy of the New York Times Book Review, stating that the volume "contains more facts about the past, present and future of such forces than have ever been put in one place before...a meticulous and responsible work that can be used with great confidence." [34] [35] Though he did not know it at the time, the public endorsement from Bundy would later play a key role in his fundraising efforts for what would become the NRDC-USSR joint verification project.

In the early months of 1986, Cochran and his *Nuclear Weapons Databook* coauthor William M. Arkin first, "half-jokingly discussed setting up seismic stations around the Nevada Test Site to guarantee that there would be no more secret tests at NTS." [36] [37] They agreed the idea was unlikely to be met with serious political

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[31] Cochran, Thomas. Personal interview. 01 April 2020.

[32] For a detailed description of the background and contents of the books as well as the motivations of the authors, see Norris, Robert S., Cochran, Thomas B., and Paine, Christopher E. "A History of NRDC's Nuclear Activities." NRDC Files. September 8, 2010.

[33] While at the time of publication the paper had little impact on the Reagan administration's policies, it did influence Chris Paine, who worked with Senator Edward M. Kennedy to pull together undecided house Democrats and convince them of the feasibility of a 1 kiloton test ban, a position adopted by the later Clinton Administration. Cochran, Thomas. Personal interview 01 April 2020 and "Chris Paine - Short Bio" *Nuclear Watch.* Web.

[34] Cochran, Thomas. Personal interview. 01 April 2020.

[35] The original review was not available. Here Bundy, McGeorge quoted in "Earth Shattering New Titles" *Bulletin of Atomic Scientists,* August 1984.

[36] Bath, Kai-Henrick "Catalysts of Change: Scientists as Transnational Arms Control Advocates in the 1980s" *OSIRIS.* 2006: 21. pg. 191.

[37] On August 23, 2010, almost 50 years after the last US nuclear test, the Nevada Test Site was renamed the Nevada Nuclear Security Site to emphasize the US commitment to cessation of testing and eliminate confusion. Here, the historical name is used where appropriate. For more information on the name transition, see https://www.nti.org/gsn/article/nevada-test-site-renamed/

consideration within the Reagan administration or from the Soviet Union, which at the time had yet to openly relax its stance on on-site inspection, let alone monitoring. Cochran drafted a plan nonetheless, playing the political considerations of the Reagan and Gorbachev Administrations off each other. As described by Kai-Henrick Barth in his work on Cold War scientists as transnational actors:

> "the Reagan administration was not interested in seriously testing the Soviets' position on verification. This, in turn, would demonstrate that the real reasons behind the Reagan administration's opposition to a nuclear test ban was not the verification problem but the determination to develop and test the next generation of nuclear weapons. Such a position was politically costly in the mid-1980s in the light of the popular Nuclear Weapons Freeze Campaign. The NRDC plan would also call the Soviets' bluff: the Soviets had repeatedly claimed that the technical means of verification were sufficient to monitor a nuclear test ban. If they rejected the NRDC's proposal, it would demonstrate to the world that the Soviets, too, were unwilling to seriously consider a test ban." [38]

Armed with his draft proposal. Cochran approached various individuals, including the late Vitaly Churkin, second secretary of the Soviet Embassy to Washington who would later go on to become Russian ambassador to the United Nations, and director of the Federation of American Scientists Jeremey Stone. [39] While the results of the first meeting were disappointing as Churkin had pushed too strongly for a proposal which would tacitly endorse the Soviet political position, the

[38] Barth, 2006, pp 191-192.
[39] Cochran, Thomas. Personal Interview. 01 April 2020.

second represented an important shift in Cochran's efforts for a joint experiment, which he initially thought would involve a letter to Reagan and Gorbachev proposing collaboration as a first step. If politicians are the primary stumbling blocks, Stone suggested, why not approach the Soviet Academy of Sciences instead? [40] Following this lead, Cochran approached physicist Frank Von Hippel, chairman of the Federation of American Scientists (FAS) with his idea. By 1983, Von Hippel was already a well-known arms control advocate, having worked with Senator Edward Kennedy to drum up support for the Nuclear Freeze movement and established ties with Evgeny Velikov, the Vice Chair of the Soviet Academy of Sciences and head of the USSR's fusion program. [41] [42] Von Hippel agreed to talk to Velikov about the possibility of hosting a workshop on seismic verification. In 1985, at the suggestion of Velikov, von Hippel gathered together a group of scientists for a 1986 meeting at the Soviet Academy headquarters. [43] Before leaving Washington, Adrian DeWind, chairman of the NRDC, met with Deputy Secretary of State John C. Whitehead and Senator Kennedy to brief them on the planned trip. Whitehead followed up the meeting with a letter, urging the von Hippel to keep in mind US government policy, but did not try to discourage them from going. With this tacit approval, the group of scientists from the NRDC, spearheaded by Cochran, the United States Geological Survey (USGS), and the Five Continent Peace Initiative headed to Moscow. [44]

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[40] Ibid.

[41] Frank Von Hippel had forged these ties as early as 1983, when he and Federation of American Scientists colleagues had accepted an invitation from the Soviet Academy scientists in the Committee of Soviet Scientists for the Defense of Peace Against the Nuclear Threat to discuss arms control issues in Moscow. "US-Russian Lab-to-Lab Nuclear Cooperation Timeline" *Doomed to Cooperate.* pp. xiii.

[42] Von Hippel, Frank. "FAS's Contribution to Ending the Cold War Nuclear Arms Race" Federation *of American Scientists Public Interest Report.* 2016. pp 1-2.

[43] Ibid.

[44] The US State Department would become a significant supporter of the project, helping expedite bureaucratic measures involved in the transportation of equipment. Cochran, Thomas. Personal Interview. 01 April 2020. See also Schrag, Phillip G. *Listening for the Bomb.* 2018.

The propositions of joint collaboration were met with interest by Soviet academicians. The American groups – the United States Geological Survey, the Five Continent Peace Initiative, and the National Resources Defense Council – each briefed their plans to their counterparts at the Academy of Sciences. The first found little traction, the second was found to be constrained by the Initiative's relationship with its government sponsors, elevating the NRDC plan to the top. As Cochran remembers, Velikov "immediately saw the value in what I proposed." [45] The NRDC team had brought along Chairman DeWind and was therefore able to get immediate approval to move forward with the plan when Velikov returned to them after the weekend with the approval of Soviet leadership. As negotiations began on the number and location of stations and funding responsibilities, DeWind had the foresight to go immediately to the office of the New York Times in Moscow. On May 29, 1986, news of the agreement was emblazoned in the first section of the Times under the heading "New Yorkers Sign Soviet Test Pact," playing on the unusual private nature of the partnership, directly under a photo of an East German guard detaining a Western Diplomat at Checkpoint Charlie. [46] The article was a major break. With marching orders from Velikov, who stated after signing "I want you back in a month," the American scientists departed Moscow. [47] Shortly after returning to New York, the NRDC scientists attended a meeting of the city's major philanthropic organizations, including the Carnegie, Ford, and Rockefeller Foundations. The representatives, having seen the papers and already being familiar

[45] Cochran, Thomas. Personal Interview. 01 April 2020.
[46] Taubman, Phillip. "New Yorkers Sign Soviet Test Pack." *The New York Times.* May 29. 1986.
[47] Cochran, Thomas. Personal Interview. 01 April 2020.

with Cochran and Arkin through their work on the *Nuclear Weapons Databook*, helped them raise half a million dollars "on the spot." [48]

Both groups of scientists, American and Soviet, had to overcome significant resistance in order to move forward with their plan. The reciprocal incursion of Soviet scientists onto territory surrounding the Nevada Test Site was met with fierce resistance from the American bureaucratic security structure. [49] Soviet scientists also had their own institutional opposition to overcome. Both the Ministry of Defense (MO) and the Ministry of Medium Machine Building (Minsredmash), fiercely opposed the initiative. [50] [51] Through his close relationship with Premier Gorbachev, Velikov was able to address the primary concerns of Soviet leadership and secure the necessary permits for the American scientists. [52]

In accordance with the agreement, the Soviet Academy of Sciences and the National Resources Defense council would construct six seismic monitoring stations – three on the lands surrounding the Nevada Test Site and three around the Soviet testing polygon in Semipalatinsk. [53] With this purpose in mind, the group of

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[48] Ibid.
[49] A detailed discussion of the political battles between the US State Department (DOS) and Department of Defense (DOD) is outside of the scope of this paper. For an in-depth analysis of the arguments involved, see Schrag, Philip G. *Listening for the Bomb: A Study in Nuclear Arms Verification Policy*. New York, Routledge, 2018.
[50] Амрамина, А. А. and Пилипенко В. А. "Советско-американский проект по мониторингу подземных ядерных испытаний: научные, социальные и политические аспекты." *Вестник ОНЗ РАН,* Том 10. NZ1103. July 2018. pp. 4.
[51] The Ministry of Medium Machine Building of the Soviet Union was established as a part of the State Defense Committee in 1945, setting as its goal "the quickest possible elimination of the US nuclear monopoly on nuclear weapons." Mikhaylov, Viktor Nikitovich. *I am a Hawk: Memoirs of Atomic Energy Minister Mikhaylov*. (1996). The Pentland Press Ltd. Hutton Close. Print. Pp. 101.
[52] Cochran, Thomas. Personal interview. 01 April 2020.
[53] Barth, pp. 198.

American and Soviet scientists arrived in Karkaralinsk, Kazakhstan on July 9, 1986.[54] American scientists and their Soviet partners inhabited adjacent trailers, nicknamed "Soviet Winnebagos" by the Americans, living and working in close quarters for the duration of the monitoring experiment. [55] [56] While no nuclear tests were recorded due to Gorbachev's moratorium, the seismic data gathered from earthquakes, chemical mining explosions, and background noise was enough to determine that key geological differences existed between the American and Soviet testing sites. [57] The previous American understanding of Semipalatinsk's geology – which was estimated but never measured and likely lay at the core of U.S. accusations of TTBT noncompliance – was found to be fundamentally incorrect. They concluded that, if explosions of identical yield were to be conducted at the NTS and Semipalatinsk, based on seismic readings, the later would appear twice as large. This finding had the key political implication of supporting the Soviet position that they had been compliant with the TTBT and PNET treaty, as well as their voluntary moratorium, all along, and undermining the Reagan administration's accusations to the contrary. [58] It was later determined that this difference was attributable to geological history of each site. While the Semipalatinsk region had been geologically stable for "hundreds of millions of years," the Nevada site had seen more recent volcanic activity and, as a result, produced a smaller wave. [59] A second major technical achievement to come of the NRDC-USSR collaboration was the operational validation of seismic methods of monitoring, which confirmed the operational feasibility of seismic verification methods to monitor underground

[54] Barth, pp. 200.
[55] Ibid.
[56] Cochran, Thomas. Personal interview. 01 April 2020.
[57] Barth, pp. 201.
[58] Cochran, Thomas. Personal interview. 01 April 2020
[59] Gordon, Michael R. "Reagan Plan on Verifying Nuclear Test Faulted: Intelligence Officials Propose Far Broader Approach." *The New York Times*. January 13, 1987.

nuclear explosions with very low yield. [60] This key finding would later contribute to the debate over the precise technical means by which to conduct the inter-lab Joint Verification Experiment.

In addition to the NRDC-USSR verification projects' clear technical achievements, in the public arena, the NRDC applied an effective three-pronged approach to nuclear advocacy – combining their unique competencies in scientific expertise, litigation, and public education. [61] Key to this was savvy utilization of the American and international news media, which allowed them to secure the funding needed for the implementation of their ideas, and to exploit the popular sentiment that had been building for years in the United States surrounding the anti-nuclear weapon movements in order to drive political movement on verification forward. Additionally, the operational experience of working together and the demonstrative nature of the experiment served to both increase the level of trust between the parties involved and help move their respective governments towards a similar intergovernmental agreement.

Trust was a critical factor in the organization and implementation of the project. While scientists like Cochran and Velikov primarily worked within their own administrations rather than directly with each other, they each had to rely on the word and efforts of the other to clear a path for their entry into the other's respective country - "a lot of this was done independently, just trusting each other,"

[60] "Совместный эксперимент: ответы на вопросы корреспондента ТАСС руководителя группы советских специалистов вылетающих на Невадский испытательный полигон." *Красная звезда.* No. 140 (19627). 18 июня 1988 г.
[61] Norris, Robert S., Cochran, Thomas B., and Paine, Christopher E. "A History of NRDC's Nuclear Activities." NRDC Files. September 8, 2010.

describes Cochran. [62] At both the organizational and implementation level, the experience of working together through significant technical and political hurdles to realize the shared vision of cooperation on seismic verification engendered mutual trust and productive working relationships which would reach their peak in the late 1980s and early 1990s. [63] In a letter dated January 10, 1986, Cochran described the motivation behind the initiative "This [plan] would not be a government effort but a citizen's initiative. The citizens would do what their respective governments failed to accomplish." [64] In reflecting on the cooperation, Cochran characterized the understanding that he and Velikov came to share:

> "It is difficult to get policy makers to pay attention to what you have to say no matter how thoughtful or scholarly your report or publication may be. But if you perform a demonstration; putting scientists in the field and invite the press and dignitaries to witness the event, the demonstration is likely to have a far greater political impact. Moreover, one should not underestimate the value of NGO [non-governmental organization] and lab-to-lab collaborative projects that demonstrate that adversaries can work together to improve the relationship." [65]

Soviet scientists from the Department of Earth Sciences within the Soviet Academy of Sciences [Отделение наук о Земле Российской академии наук]

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[62] Ibid.
[63] Technical challenges included, but were not limited to, adapting Soviet data processing techniques to accommodate the output from American sensing equipment. Амрамина, А. А. and Пилипенко В. А. pp 7.
[64] Letter from Thomas Cochran to Sidney Drell and Richard Garwin. January 10, 1986. Sited in Krepon, Michael. "Joint Verification Experiments," *Arms Control Wonk.* January 11, 2011.
[65] Cochran, Thomas B. "The Black Sea Experiment" January 19, 2011.

(OHZ SAS) echoed the conclusion that the demonstration was an important factor in the success of the project: only through working together was the unreliability of methods of control of nuclear testing, something which had for many years been a subject of controversy and a pretext for delaying negotiations, overcome. [66] The groundbreaking experiment, the very idea of which was unthinkable before 1986, set the precedent for direct information exchanges and technical cooperation and ushered on a host of further cooperative initiatives, including the Joint Verification Experiment. [67] The explicitly civilian nature of the NRDC program, as well as its stated goal of proving that private individuals could accomplish what governments could not, may have influenced the rapid roll out time for the JVE initiative, as government scientists sought to reassert their prerogative as the authoritative purveyors of verification technology for nuclear arms control.

Cooperative Testing comes to the Labs: The Joint Verification Experiment

The Joint Verification Experiment, conducted between scientists of the American and Soviet National Nuclear Weapons Laboratories, has been described as the "precursor to Lab-to-Lab cooperation." [68] Like the NRDC-USSR verification experiment, which strategically utilized the involvement of journalists to advance

[66] Original text: "Недостаточная надежность методов контроля ядерных испытаний на протяжении многих лет оставалась предметом споров, поводом для взаимного недоверия и предлогом для затягивания переговоров о запрещении ядерных испытаний между США и СССР во время холодной войны." Quoted from Амрамина, А. А. and Пилипенко В. А. "Советско-американский проект по мониторингу подземных ядерных испытаний: научные, социальные и политические аспекты." *Вестник ОНЗ РАН,* Том 10. NZ1103. July 2018.
[67] Амрамина, А. А. and Пилипенко В. А pp. 2.
[68] Voloshin, Nikolai. "Scientific and Technical Cooperation between the Nuclear Weapons Institutions of the USSR and USA for the Joint Verification Experiment." *Doomed to Cooperate Volume I,* edited by Sigfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. pp. 109.

public engagement on the nuclear test ban debate, the 1988 JVE took place "on the world stage." [69] The first delegation of 20 Soviet scientists and arms control experts arrived in Nevada on January 26, 1988 to familiarize themselves with the Nevada Test Site in preparation for the experiment. [70]

The design and implementation of the experiment required heavy technical cooperation between both teams. Because of the complexity of the complexity of the hydrodynamic method chosen to measure yield, this collaboration was close and multifaceted. Teams worked together on determining equations for the state of the rock across the range of temperature and pressure conditions, in modeling that shock wave propagation, and in correlating their data to with the yield of the detonation. [71] Because one of the primary concerns for each party was the risk of accidentally revealing sensitive data to the other team, specifications for anti-intrusion devices (AIDs) were jointly developed, independently built, and then subjected to rigorous cross testing to validate the other team's construction. [72] Describing AID development in particular, Nikolai P. Voloshin of All-Russian Scientific Research Institute of Technical Physics (VNIITF) called it "without a doubt … one off the earliest examples of collaboration that was inherent in the lab-to-lab cooperation."

[69] Robinson, Paul C. "The Joint Verification Experiment and Nuclear Testing Talks: Important Precursors to the US-Russian Lab-to-Lab Program." *Doomed to Cooperate Volume I,* edited by Sigfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. pp. 84.
[70] James, Jesse. " Soviet Experts Tour U.S. Nuclear Test Site." *Arms Control Today.* Vol. 18, No. 2. March 1988. pp. 25.
[71] Voloshin, Nikolai P. "Scientific and Technical Cooperation between the Nuclear Weapons Institutes of the USSR and USA for the Joint Verification Experiment." Doomed to Cooperate Volume I, edited by Sigfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. pp. 104.
[72] This development would begin in 1988 and last until 1992. Ibid. 106.

[73] The exchange encompassed the relatively mundane details. [74] Soviet scientists, for example, had developed a clear and simple naming convention for their tests, referring to each detonation using the serial number of the borehole. The American DOE scientists, in stark contrast, preferred to give "proper," if apparently arbitrary, names to their nuclear tests. [75] [76] For the purposes of the Joint Verification Experiment, the both scientists would follow the American president; naming the NTS test "Junction" or "Kearsarge" after a small Native American area near the test cavern location and the Semipalatinsk test "Shagan" or "Chagan" after a tributary of the Irtysh River in the Balapan steppes. [77] [78]

Mikhailov would later recount in his memoirs with detailed and poetic prose the moments leading up to an underground nuclear test; following the first outward signs of successful detonation downfield:

> "All observers stand still, deep in their own though, and only a dozen or so seconds later comes a muffled earth's groan. It was like this [the earlier detonations he had supervised at the Semipalatinsk Test site] in

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[73] Ibid.

[74] For a more detailed description of the operational differences in the American and Soviet approach to testing and the Soviet perspective upon visiting the Nevada Test Site, see Voloshin, Nikilai P. *Trust but Verify* (RFNC-VNIITF Publishers, Snezhinsk, 2013).

[75] Mikhaylov, Vikor Nikitovich. *I am a Hawk: Memoirs of Atomic Energy Minister Mikhaylov.* (1996). The Pentland Press Ltd. Hutton Close. Print. Pp. 24.

[76] Beginning in 1961 with Operation Nougat, U.S. tests were grouped into series based on the fiscal year they were conducted for reporting purposes, but operation names themselves followed no clear or consistent convention. "United States Nuclear Tests: July 1945 through September 1992." DOE/NV--209-REV 16. NNSA/NSO Nuclear Testing Archive.. Nevada Nuclear Security Site, Las Vegas, NV. Online.

[77] The artificial *Atom-kul'* reservoir created in those steppes left a strong negative impression on Mikhailov and influenced his belief that "peaceful nuclear explosions" had no place near inhabited regions. Mikhaylov (1996) pp. 33.

[78] "United States Nuclear Tests: July 1945 through September 1992." and Mikhaylov (1996) pp. 24.

> 1988 at the US-USSR Joint Experiment which aimed at mastering the techniques for verifying the yield of the underground nuclear explosions whose signal travelled around our planet as a signal of hope for a nuclear free world … the Earth became transparent for such a signal." [79]

Just as was the case with the private scientists engaging in nuclear verification experiments at the time, the operational experience of working with their Cold War adversaries left a lasting impact on the national laboratory scientists involved and served to increase the trust, and thus the case for deepened collaboration, between the parties involved. "Initially, there was much apprehension and an expectation that the human interface would be quite adversarial at all levels," remarked JVE Lead EG&G Engineer Eric Jorgenson. [80] In the early stages of both experiments, he remembers some posturing between both scientific teams as each felt the other out. As both sides learned to effectively handle the expectations and professional culture of the other "this behavior would eventually solidify long-lasting friendships between many of the US technical team and the Soviet technical team...in the long run, long term relationships were established in spite of national and political differences, which seemed to be alleviated after working together." [81] Some of these friendships, for example that between VNIITF's Nikolai Voloshin and LANL's Don Eilers, would come to span decades. [82] As remembered by Soviet academician Evgeny N. Avrorin: "For me, the Joint Verification Experiments were key to all of

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[79] Mikhaylov, Vikor Nikitovich. *I am a Hawk: Memoirs of Atomic Energy Minister Mikhaylov.* (1996). The Pentland Press Ltd. Hutton Close. Print. Pp. 24.
[80] Jorgenson, Eric. Personal communication. 07 April 2020.
[81] Ibid.
[82] Voloshin, Nikolai P. "Scientific and Technical Cooperation between the Nuclear Weapons Institutes of the USSR and USA for the Joint Verification Experiment." Doomed to Cooperate Volume I, edited by Sigfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. pp. 106-107.

our future collaborations. The JVEs were unique. Both sides developed a level of trust in each other. We managed to do our work in a step-by-step process to build confidence and trust." [83] One particular comment by an American scientist at the Semipalatinsk stage of the experiment stuck with him and encapsulated this feeling: "I imagined Soviet people in an absolutely different way. Now, as we become familiar with people, I can't imagine how we could start a war with each other. Now I see they are people just like us." [84] The experience of working closely with, and in many cases, living alongside, their counterparts, served to humanize their former Cold War adversaries. Many of the participating scientists left deeply affected by the experience. "Direct contacts between scientists were so important in this process," Mikhaylov would later echo in the same tenor as the unnamed American scientist whose point so struck Avrorin, "when we walked around Washington, New York, and Las Vegas, I could not imagine, even in a flight of scientific and technical fancy, those wondrous cities as 'military targets.' "[85] In recounting the experiment, Mikhaylov made clear his belief that the "main result" of the JVE was not the technical means of test ban verification which they had set out to develop, but rather the rare change for close interpersonal communication and interaction with their counterparts. [86]

The Joint Verification Experiment served to increase trust not only between the participants involved, but with the citizens of their respective countries as a

[83] Avrorin, Evgeny N. "Just Like Us". *Doomed to Cooperate Volume I,* edited by Sigfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. pp. 82.
[84] Ibid.
[85] Las Vegas seemed to leave a particularly strong impression on Mikhaylov, because of its harsh arid climate starkly contrasting with the Soviet test sites on which he had previously worked and the memories of his experience as a refuge in 1941 which the wildfires evoked. Mikhaylov, Vikor Nikitovich. *I am a Hawk: Memoirs of Atomic Energy Minister Mikhaylov.* (1996). The Pentland Press Ltd. Hutton Close. Print. Pp. 69-72.
[86] Ibid. pp. 71.

whole through their savvy utilization of the media. While the United States National Laboratories found themselves necessarily confined by US Department of Energy (DOE) security policies in ways which the scientists of the NRDC did not, transparency was nevertheless a core consideration, and factored centrally into the planning and execution of the JVE. United States scientists preparing for the arrival of their Soviet counterparts in Nevada felt acutely the historical burden on their shoulders. They recognized the opportunity which presented itself with the anticipated wave of public interest that would follow the arrival of Soviet nuclear scientists on American soil. As summarized in an internal DOE public affairs plan, the Joint Verification Experiment "is part of the US overall negotiations with the Soviet Union on arms control...on its own, however, it [is] also an [sic] historic event. There will be extraordinary interest in the JVE by the public and the news media. The credibility of the JVE with the media, and through the public, can directly affect Congressional acceptance of pending and future arms control agreements. The key to JVE credibility is news media." [87]

Soviet scientists were a central part of the public relations strategy surrounding the joint verification experiment from the beginning. Criticisms from hawkish journalistic factions were expected, and care was taken to explain to the Soviet delegation, comprising primarily scientists rather than experienced politicians, the independent role of the American media and to help them devise a strategy for fielding reporters' questions. [88] Commentary from the Soviet delegation, as well as photo opportunities in select approved areas, were encouraged.[89] Soviet

[87] "Public Affairs Plan for Joint Verification Experiments" NV318979. NNSA/NSO Nuclear Testing Archive. Nevada Nuclear Security Site, Las Vegas, NV. Accessed: March 2020
[88] Ibid.
[89] "Public Affairs Plan for Soviet Orientation." NV319254. NNSA/NSO Nuclear Testing Archive. Nevada Nuclear Security Site, Las Vegas, NV. Accessed: March 2020

television, radio organizations, and TASS reporters were also invited to work alongside Western media outlets reporting on the experiment, though other Soviet bloc journalists were only invited to briefings held offsite.[90] Interest was such that media teams were even granted access and filming privileges to such mundane events as the loading of American drilling equipment onto C5-B aircraft at Indian Springs Airbase for transportation to the Soviet Union.[91] Even as they strengthened working relationships with each other, American and Soviet scientists were working together to improve the image of verification in the eyes of the public and the trust they felt in each country's commitment to limiting nuclear testing.

Differing Technical Approaches to Cooperative Verification

Despite the apparent shared goal of exploring cooperative test ban verification measures with the Soviet Union, a clear rhetorical line was drawn in US Department of Energy Documents between the initiatives of private scientists, and similar work done subsequently by US and Soviet National Laboratories. One such document from the early planning of the Joint Verification Experiment described the goal of the public affairs team, in part, as "to differentiate it [the JVE] from the other "verification experiments" [sic] being conducted unofficially by private individuals from the U.S. and Soviet Union." [92] Likewise, no mention of the NRDC verification experiment, is made in DOE newsletters describing the chronology of events leading to the JVE. Dr. Siegfried Hecker's authoritative book on US-USSR lab to lab engagement, *Doomed to Cooperate,* spends a significant amount of time discussing the JVE, which contributor Ambassador C. Paul Robinson of Sandia National

[90] Ibid.
[91] Ibid.
[92] "Public Affairs Plan for Joint Verification Experiments" NV318979. NNSA/NSO Nuclear Testing Archive. Nevada Nuclear Security Site, Las Vegas, NV. Accessed: March 2020

Laboratory described as "a defining event in the history of technical interactions between the United States and Russia," but comparatively little time on the NRDC-USSR work as a precursor. [93] [94] [95] Nevertheless, Cochran and NRDC scientists describe very good relations with laboratory colleges at the inter-scientist level. DOE laboratory scientists were consulted before and during the projects and were often involved in workshops headed by the NRDC following the conclusion of its venture into joint experimentation. [96]

The primary point of contention between the two sides of cooperative Test Ban initiatives debate, public and private, was technical, rather than political in nature. National Laboratory scientists and U.S. government officials advocated for the use of Continuous Reflectometry for Radius versus Time Experiments (CORRTEX) hydrodynamic system for nuclear yield measurement to be employed in the JVE and subsequent verification, maintaining that it was more accurate than the seismic verification systems. Such systems, like the teleseismic method used by the NRDC and Soviet Academy scientists the years prior, record the amplitude of seismic vibrations as they propagate through the earth. In contrast to seismic verification stations, which can be deployed at a distance of 3,000 - 10,000 kilometers from the test cavity, hydrodynamic methods require the installation of

[93] Robinson, C. Paul. "The Joint Verification Experiment and Nuclear Testing Talks: Important Precursors to the US-Russian Lab-to-Lab Programs." *Doomed to Cooperate Volume I,* edited by Siegfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. pp. 84.
[94] Chronology of Historical Events and Negotiations Leading to Joint Verification Experiment." No Date. NV0320159. NNSA/NSO Nuclear Testing Archive. Nevada Nuclear Security Site, Las Vegas, NV. Accessed: March 2020.
[95] Later NRDC efforts, including the Black Sea experiments, are given more prominence in the book. Dr. Siegfried Hecker would also later write a kind personal letter to Dr. Thomas Cochran, apologizing for not giving him enough credit in his work. Personal communication with Thomas Cochran, April 2020.
[96] Barth, 192 and Cochran, Thomas. Personnel interview. 01 April 2020.

sensing equipment in close proximity to the nuclear device in order to record the location of the front of the initial shock wave as it moves through the ground in close proximity to the epicenter of the detonation. [97] The U.S government's central claim – that CORRTEX could offer a more accurate picture of each party's yield – was met with resistance from outside members of the American technical community, including Gregory van der Vink, who spearheaded the 1988 Seismic Verification Study for the US Office of Technology Assessment (OTA), who also drew attention to the fact that "a full network of seismic stations recording data continuously for all test explosions could be built and installed within the Soviet Union for approximately the cost of a single CORRTEX measurement. [98] [99] Additionally, because the CORRTEX system relies on a cable installed adjacent to (or within) the shaft housing the device to be to tested, it is incapable of conclusively detecting tests at a distance of greater than "a few dozen" meters, which contemporary critics contended, severely limited its potential as a verification mechanism for a comprehensive test ban. [100] Soviet scientists taking part in JVE, felt similarly that the previously implemented teleseismic method of verification was more than sufficient, as it had both been proven effective in the early NRDC-Soviet Verification Experiment and did not necessarily require onsite personnel to conduct.

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[97] At this close distance, for a treaty compliant 100-150 kiloton yield, the front of this shock wave moves at supersonic speeds and the ground surrounding the blast within this area behaves as if liquid, rather than rock; hence the name "hydrodynamic." "Совместный эксперимент: ответы на вопросы корреспондента ТАСС руководителя группы советских специалистов вылетающих на Невадский испытательный полигон." *Красная звезда.* No. 140 (19627). 18 июня 1988 г.

[98] D.L., "Senate Considers Testing Treaties," *Arms Control Today.* Vol. 20, No. 7. September 1990. pp. 19.

[99] For more information on technical disagreements pertaining to the CORRTEX system, including concerns over the reliability in detecting very low yields, see Sykes 1987 and Everden 1985.

[100] Halverson, Thomas E. "Limited Movement in Nuclear Testing Talks." *Arms Control Today.* Vol. 19. No. 7. September 1989. pp. 30.

The extensive lead time required for the preparation of a single CORRTEX test and the difficulty of transporting the drilling equipment needed to the more remote Soviet test sites, also decreased its utility as a verification tool from the perspective of Soviet scientists. Nonetheless, the USSR eventually ceded to U.S. government insistence on the CORRTEX method. [101]

Allegations abounded at the time, most notably in an October 1988 Report, that the US government's insistence on the utilization of the CORRTEX method was not solely, or even primarily, based on technical concerns about its accuracy or reliability but, rather it would create the "appearance of progress" to divert attention from the movement for a Comprehensive Test Ban, without offering any operationally useful solutions. [102] Former director of Lawrence Livermore National Laboratory John Nuckolls eventually did admit "it may be possible to obtain effective monitoring primarily with seismic measurements." after recalibration of seismic methods using measurements from the CORRTEX system. [103] Despite the lack of publications clearly linking the two initiatives, the impact of the NRDC-USSR joint verification project on the later Joint Verification Experiment should not be discounted. As Cochran put it, "We were doing lab to lab work, in effect, before the lab to lab program." [104]

[101] "Совместный эксперимент: ответы на вопросы корреспондента ТАСС руководителя группы советских специалистов вылетающих на Невадский испытательный полигон." *Красная звезда.* No. 140 (19627). 18 июня 1988 г.
[102] Sited in another publication, working on obtaining original
[103] Ibid.
[104] Chochran, Thomas. Personnel interview. 01 April 2020.

Effect of Technical Cooperation of Verification Negotiations

Technical cooperation on test ban treaty verification, according to Mikhaylov, would later become the first minister of the new Russian Atomic Energy Ministry, "was the basis of progress at the negotiations in Geneva." [105] The open and professional nature with which US and Soviet technical teams were able to conduct discussions with one another, as well as the mutual scientific understandings born of joint experimentation, allowed negotiations to proceed quickly despite the unprecedented technical scope and depth of the verification measures outlined. [106] A key consideration which, in the absence of technical cooperation on Joint Verification, would likely have presented significant challenges at the negotiating table was the admissibility of on-site measurements and their anti-intrusive instrumentation. [107] In the end, the Protocol to the Treaty of 1974, signed in 1990, was the product of only three years of bilateral negotiations. [108] The joint experience in technical cooperation certainly had a positive effect on the negotiations – both by establishing rapport between the two teams and in laying the groundwork for common understandings which allowed them to proceed quickly to more complicated issues. Where political will alone had not been enough to ensure progress on the full implementation of the Test Ban Treaties, robust verification

[105] Mikhaylov, Vikor Nikitovich. *I am a Hawk: Memoirs of Atomic Energy Minister Mikhaylov.* (1996). The Pentland Press Ltd. Hutton Close. Print. pp. 82.
[106] Ibid.
[107] While onsite inspections had been first agreed to in principle during negotiations for the Intermediate Range Nuclear Forces Treaty signed in 1987, scientists participating in the JVE would be the first technical experts from their respective countries sent abroad for the purposes of on-site verification.
[108] Mikhaylov, Vikor Nikitovich. *I am a Hawk: Memoirs of Atomic Energy Minister Mikhaylov.* (1996). The Pentland Press Ltd. Hutton Close. Print. pp. 82.

protocols, based on shared understanding and experience, helped to clear the air of misunderstanding and move implementation forward.

Cooperative Doors are Opened

The success of the collaborative test ban verification projects, in addition to their technical and political contributions, opened the doors for increased technical cooperation in arms control between American and Soviet, and later Russian, scientists, both in the private and government sectors. Building upon the contacts established during the Test Ban Verification Project, described by participating Soviet scientists as "one of the bright pages of Russian geophysics," the National Resource Defense Council went on to establish a "close working relationship" with the Russian Academy of Sciences that lasted through the end of the decade. [109] [110] Cochran and Velikov, for their part, went on to collaborate in a set of other experiments aimed at assessing the viability of different passive radiation detects for warhead verification at sea, collectively called "the Black Sea Experiment." [111] The United States government, for its part, vehemently opposed the exercise on the grounds that reciprocal visits, which could realistically be expected by Soviet scientists, could potentially leak sensitive technical information. [112] Factions within the Russian government also expressed hesitancy. Academician Yuli B. Khariton, the director of Arzamas-16 – Los Alamos's "sister city" and home to All-Russian Scientific Research Institute of Experimental Physics (VNIIEF) – who would

[109] Амрамина, А. А. and Пилипенко В. А. "Советско-американский проект по мониторингу подземных ядерных испытаний: научные, социальные и политические аспекты." *Вестник ОНЗ РАН,* Том 10. NZ 1103. July 2018.
[110] Cochran, Thomas B. "Black Sea Experiment only a Start," *Bulletin of Atomic Scientists*. Nov. 1989. pp. 13.
[111] Cochran, Thomas B. "The Black Sea Experiment" January 19, 2011.
[112] Ibid. 14.

become foundational in the Lab-to-Lab initiatives of the 1990s, protested against the experiment to party officials. It was only with Gorbachev's direct intervention that a warhead was finally made available for the experiment. [113] While little in the way of immediate concrete limitations on submarine launched ballistic missiles (SLBMs) came out of the venture, the Black Sea experiment reinforced an earlier Soviet finding that, despite their limitations, passive radiation detectors still had the potential to serve as a useful tool for warhead verification.[114] In addition to their technical goals, NRDC scientists used the opportunity presented by the experiment to extend their public education mission to new audiences in the Soviet Union. NRDC scientists presented their counterparts with copies of their *Nuclear Weapons Databook IV* on the Soviet arsenal, which were met with great interest.[115] The "most remarkable achievement" however, as Cochran remarked, "was the exercise itself. The Soviet government permitted U.S. scientists to measure radiation from an operational warhead on a principal Soviet combatant." [116] Arguably, an achievement of this magnitude would not have been possible, had it not been for the relationships and trust built in 1986. In reaching these conclusions, the involvement of private

[113] Private communication with Frank von Hippel, cited in Cochran "The Black Sea Experiment." January 19, 2011.
[114] Following the experiment, Chairman of the Joint Chiefs of Staff General Colin L. Powell raised objections with the idea of removing nuclear warheads from naval carriers, arguing that their storage onshore was inconsistent with US naval operational procedure. President Bush would only reverse this stance in 1991 with a series of unilateral reductions, including the removal of sea-based Tomahawk cruise missiles to central storage locations.
[115] For an example of the impact of the exchange, when the Center for Arms Control, Energy, and Environmental Studies was established in 1990 at the Moscow Institute for Physics and Technology (MIPT), translation of the volume from English to Russian was one of their first projects. Additionally, following the collapse of the Soviet Union, a cohort of MIPT alumni would publish *Russina Strategic Nuclear Forces* in 1998, a similar book based on Russian, rather than English, language sources. Norris, Robert S., Cochran, Thomas B., and Paine, Christopher E. "A History of NRDC's Nuclear Activities." NRDC Files. September 8, 2010.
[116] Ibid. pp. 14.

scientists and initiatives was instrumental in moving the needle forward, even when governments resisted.

Within the government sector, cooperation reached its epoch with the Laboratory-to-Laboratory initiatives of the 1990s, the history of which is detailed extensively by the participants of those programs, both Russian and American, in Siegfried Hecker's *Doomed to Cooperate.* The relationships built between American and Soviet Scientists during the planning and implementation of the Joint Verification Experiment and subsequent Geneva negotiations did not dissolve following the program's conclusion. In 1990, while at a Moscow conference on verification, Mikhaylov would take the unprecedented state of inviting LANL and LLNL scientists to visit the Soviet Union's closed nuclear cities – something which had never before been permitted. [117] [118] By the time the first of these visits happening in February 1992, the world had changed completely. The end of the Cold War heralded in a new set of concerns and dangers, collectively referred to as the four "loose nukes." [119] The connections formed between scientists took on new importance as they rose to meet these new challenges. During this period of exchange as well, close interpersonal interactions helped to clear the air of misunderstandings and misperceptions, and lay foundations for lasting productive relationships. [120] The full history of these collaborative efforts is to extensive to be

[117] Hecker, Siegfried. "Overview" *Doomed to Cooperate. Volume I,* edited by Siegfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. pp. 31-33.
[118] In the early days of their existence, these facilities were such tightly held secrets that they did not even appear on official maps and were sometimes referred to only by a P.O. box nearby.
[119] These referred security and proliferation concerns regarding nuclear weapons, materials, experts, and exports.
[120] One of these realizations, on the American side, was Russian pride in their nuclear heritage, which had been casually referred to by some US commentators as "an inheritance from hell"

adequately covered here, but much incredible and groundbreaking came of the approximately 20 years that these exchanges flourished – encompassing both nonproliferation agreements and cooperation in fundamental science. [121]

because of the challenges posed to securing such and extensive complex in the face of rapidly changing political conditions.

[121] Some of these breakthroughs included, for example, the highest experimentally generated magnetic fields, the HEU purchase agreements, and the long running Warhead Safety and Security Exchange program. For an extensive recounting of accomplishments, see Siegfried Hecker's 538 page tome on the program: *Doomed to Cooperate. Volume I*, edited by Siegfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016.

VI. CHAPTER FOUR: A FUTURE FOR COOPERATIVE VERIFICATION?

Mikhailov, in a meeting following the Joint Verification Experiment with US specialists, remarked his hope that the technical and personal achievements of Soviet scientists in working with their counterparts would "show the American scientists that it would be better for us [the US and the USSR/the Russian Federation] to compete in the building of an environment of mutual understanding and trust rather than the development of a third generation of nuclear weapons." [122] Few American and Soviet scientists at the close of the 1980s could have predicted the events which would unfold in the following decades.

In order to access the feasibility of technical cooperation in the future, it is first necessary to examine the conditions which allowed for the success of historical cooperative efforts such as those initiated by Soviet and American scientists in the 1980s. How do political conditions – specifically, government attitudes towards technical cooperation and the relationships between states and their respective research complexes – allow for windows of opportunity in this sphere to be opened?

What Made Technical Cooperation in the 1980s-1990s Possible?

[TBA - Interviews Collected, still writing – BLUF: Open minded politicians. Scientists with political connections to cut through bureaucracy, Security need and mutual interest]

[122] Mikhaylov, Vikor Nikitovich. *I am a Hawk: Memoirs of Atomic Energy Minister Mikhaylov.* (1996). The Pentland Press Ltd. Hutton Close. Print. pp. 83.

How Do Windows of Opportunity Open and Close?

[: Technical cooperation in the arms control sphere can only happen between states when 1) there is a political will ***and*** *2) the relationships between the national security science community (national research complexes) and their respective governments are conducive to exploiting (or at least tolerating) interest in collaboration on sensitive areas. Can be understood by orienting national research complexes on a spectrum ranging from complete government direction | total secrecy to complete institutional discretion | transparency. Position on the spectrum is not static but shifts depending on political leadership and policy directions (including those governing institutional structures). Historically, movement along the spectrum has oscillated based on these factors and the current level of collaboration. When cooperation is low, there are political incentives to increase it, as cooperation increases, government/security bureaucracies intercede to curtail/check collaboration and push organizations back toward the left end of the spectrum. Both states must meet somewhere in the middle in order for collaboration to take place. This was the case in the late 1980s, when:*

- *CCCP*
    - *Gorbachev's arms control became a key political platform [necessary political will condition met]*
    - *Perestroika/Glasnost emphasized transparency and internationalization of Soviet science and Velikov's close relationship with Gorbachev allowed him freedom to pursue projects with little bureaucratic impediment. [Movement from left to right]*

- *US*
    - *Reagan Administration reversed its stance on NW issues following events on 1983 and domestic resistance arms race increased [necessary political will condition met]*
    - *Activity begans on right of spectrum with NRDC scientists which galvanized DOE scientists to push for movement in this area, which was tolerated in part because it was initiated by scientists within the academic consortia affiliated with the laboratories [Movement from right to left]*

Early collaborations on test ban verification opened the doorways for increasing cooperation in the nuclear (and later BW and CW) spheres. But this increase prompted a reaction from the security bureaucracy of Russian decrying "nuclear tourism" as more organizations outside of DOE became involved. Additionally, structural changes to DOE labs - movement away from GOCO model and formation of NNSA - changed how projects were managed and pushed the US back left. This occurred despite strong advocacy among key US leadership, including within the NNSA itself (most notably Linton Brooks). Demonstrates that political will is a necessary, but not a sufficient condition to allow for cooperation. Must have both the will and complementary and conducive institutional structures.

Current Relationships between State and Research Organizations

Legislative changes within the Russian Federation, beginning around the same time as the decline in lab-to-lab cooperative efforts in the mid-2010s, indicate that Russia's national research complex may be returning to a closer alignment with the federal government and its strategic priorities. Immediately following the collapse of the Soviet Union, a decade of underfunding in Russian fundamental

science institutions and poor understanding of and political commitment to intellectual property law left both private and public organizations struggling to compete with Western counterparts in high technology sectors. Money in the form of foreign investment proved difficult to attract, and many of the most talented Russian scientists sought more gainful employment abroad, increasing the government's concern over potential "brain drain." [123]

A series of legislative measures beginning in the late 2000's, primarily the 2013 "On RAS..." law as well as projects on educational reform, the establishment of national research centers, the Russian Science fund, special designations for universities, etc. were designed to correct this problem. The national system that emerged from the series of reforms was disjointed and lacked any coordination. The resulting fragmentation widened the technological gap between the Russian Federation and developed countries and was perceived as a threat to national security. This was addressed in the subsequent 2015 National Security Strategy of the Russian Federation (NSS), which highlighted science and technology as strategic national priorities. [124] The Strategy for Scientific and Technological Development of the Russian Federation was formulated the following year to better codify national priorities in the scientific technical sphere and provide an outline for the implementation of the goals outlined in the NSS. [125] One of the primary thrusts of the document is how Russian should address the so called " big Challenges" defined

[123] " III. Угрозы национальной безопасности Российской Федерации" КОНЦЕПЦИЯ НАЦИОНАЛЬНОЙ БЕЗОПАСНОСТИ РОССИЙСКОЙ ФЕДЕРАЦИИ. Утверждена Указом Президента Российской Федерации № 24 от 10.01. 2000 г.

[124] "О Стратегии национальной безопасности Российской Федерации" Указ Президента Российской Федерации от 31.12.2015 г. № 683

[125] Dezhina, Irina, Science and Innovations in Russia in 2018 (September 5, 2019). Russian Economy in 2018. Trends and Outlooks (Issue 40). 2019. Moscow. IEP, pp. 461-484.

as those that" objectively require a reaction form the state, this totality of problems threats and opportunities whose scale and complexity is such that they cannot be resolved, eliminated, or implemented exclusively through an increase in resources."

Within the Russian Academy of Sciences, Recent internal changes to the charter as well as comments by high ranking officials are indicative of a possible shift away from previous goals of full internationalization of the Russian scientific community and toward an understanding of science as a primarily domestic, security oriented, industry. The charter of the Russian Academy of Sciences has recently undergone legal changes to its wording, directed by Moscow, to bring it more in line with the government Security and Technical Development Strategies. The most recent took place in in 2019, amending Point 11 of the RAS charter to add to its list of fundamental activities "scientific research implemented in the sphere of the defense-industrial complex in the interests of defense to the state security of the government" and connecting it directly to the realization and implementation of government strategies and priorities in the sphere (see Appendix). [126] Additionally, in 2019, a legal framework to work with state secrets was added. The groundwork for such a shift toward sensitive government work had been laid 3 years prior, with the 2016 issuing of license No 0093121, government secret series for the "conduction of work, connected with the use of information comprising government secrets" by the FSB Center for Licensing, Certification, and the Protection of State Secrets. [127] The electoral procedure for RAN has also increasingly shifted power toward the government to approve of internal academy proceedings -- a change which is not without some historical precedent. During the Soviet Union, the Soviet Academy of Sciences elected its head through a simple majority of votes in a secret

[126] "On making changes to the charter of the federal government budget of the institutes RAS" 25.04.2019 No. 496
[127] Ibid.

ballot. In November 1991, the Russian Academy of Sciences was established as its legal successor and term limitations were added to the position. Those limitations were subsequently abolished in 2001, only to be reintroduced, along with a provision requiring the approval of the head of RAN by the president, in the revised 2007 RAN Charter. During the 2013 reforms, the prerogative of approval was once again passed to the government. [128] Further amendments in the charter in 2014 required a two thirds majority to win, in addition to government approval. Following a failed election attempt in the early months of 2017, a new bill was introduced in the Duma. The legislation restricted the number of candidates to three, all of which would require advanced government approval, and reinstated the simple majority vote. The bill passed despite some protest, particularly from a group of scientists calling themselves the "July 1st club." Restrictions on ballot size were eventually lifted but 'coordination' of candidates with the government remains. [129] Overall, the revised document, as well as the updated voting procedures, indicates a shift in focus slightly in toward greater state coordination of the national research complex and closer integration of fundamental research with the defense-industrial needs of the Russian Federation.

[128] "Как менялся порядок выборов президента РАН. Досье." Без абтора. 12 июл. 2017.
[129] Ibid.

V. CONCLUSION

Each round of transnational contact strengthened the case for future collaboration and improved trust between the parties involved. On the political side, aided by the Reagan and Gorbachev's changing attitudes towards arms control, technical cooperation of verification measures also aided the domestic political debate in their respective countries, recasting an unpalatable political problem into an approachable technical one, and whittling away at institutional opposition whose central gripe with extant test ban treaties centered on verifiability.

Reflecting on the history of verification efforts, the collaborative scientific work on test ban verification demonstrates that technical cooperation on arms control issues need not be the sole purview of governments. At a time when relations between the United States and the Russian Federation are at a historic low, technical cooperation in the sphere of arms control offers an operational path forward for the reestablishment of working relationships built on trust not freely given, but gained through experience, and a shared vision of the future. Scientists remain overwhelmingly open to collaboration – if political leadership is only willing to take a risk. In order for any future initiatives to be successful, policymakers must be open to learning from the past without repeating its mistakes. Scientific cooperation has proven to be both possible, and mutually beneficial—not just because of the technical solutions it achieves but the trust in engenders and the connections it bridges. However, the United States needs to engage the Russian Federation as a true peer-level partner, as was done in the 1980s.

As the stewards of the majority of the world's nuclear stockpile, the United States and the Russian have a unique role to play in shaping global norms on arms control verification and cooperation; it is in their mutual interest now to begin to find technical solutions to the question of verification as other countries ramp up production.

X. APPENDICES

A. ACRONYMS

CTB	Comprehensive Test Ban
CTBT	Comprehensive Test Ban Treaty
CORRTEX	Continuous Reflectometry for Radius versus Time Experiments
DOD	Department of Defense (US)
DOE	Department of Energy (US)
DOS	Department of State (US)
FAS	Federation of American Scientists
FSB	Federal Security Service (RF)
INF	Intermediate Nuclear Forces Treaty
JVE	Joint Verification Experiment
LANL	Los Alamos National Laboratory (US)
LLNL	Lawrence Livermore National Laboratory (US)
MO	Ministry of Defense (RF)
NNSA	National Nuclear Security Administration (US)
NNSS	Nevada National Security Site (Contemporary)
NRDC	National Resources Defense Council (US)
NTM	National Technical Means
NSS	National Security Strategy (RF)
NTS	Nevada Test Site (Historical)
NTR	National Strategy for the Development of

	Science and Technology (RF)
NTT	Nuclear Testing Talks
OHZ	Department of Earth Sciences SAS (RF)
PNE	Treaty on Peaceful Nuclear Explosions
PTBT	Partial Test Ban Treaty
RAN	Russian Academy of Sciences
SAS	Soviet Academy of Sciences
SLBM	Submarine Launched Ballistic Missile
STS	Semipalatinsk Test Site
TBT(s)	Test Ban Treaty (Treaties)
TTBT	Threshold Test Ban Treaty, Moscow Treaty
VNIIEF	All-Russian Scientific Research Institute of Experimental Physics
VNIITF	All-Russian Scientific Research Institute of Technical Physics

B. FIGURES

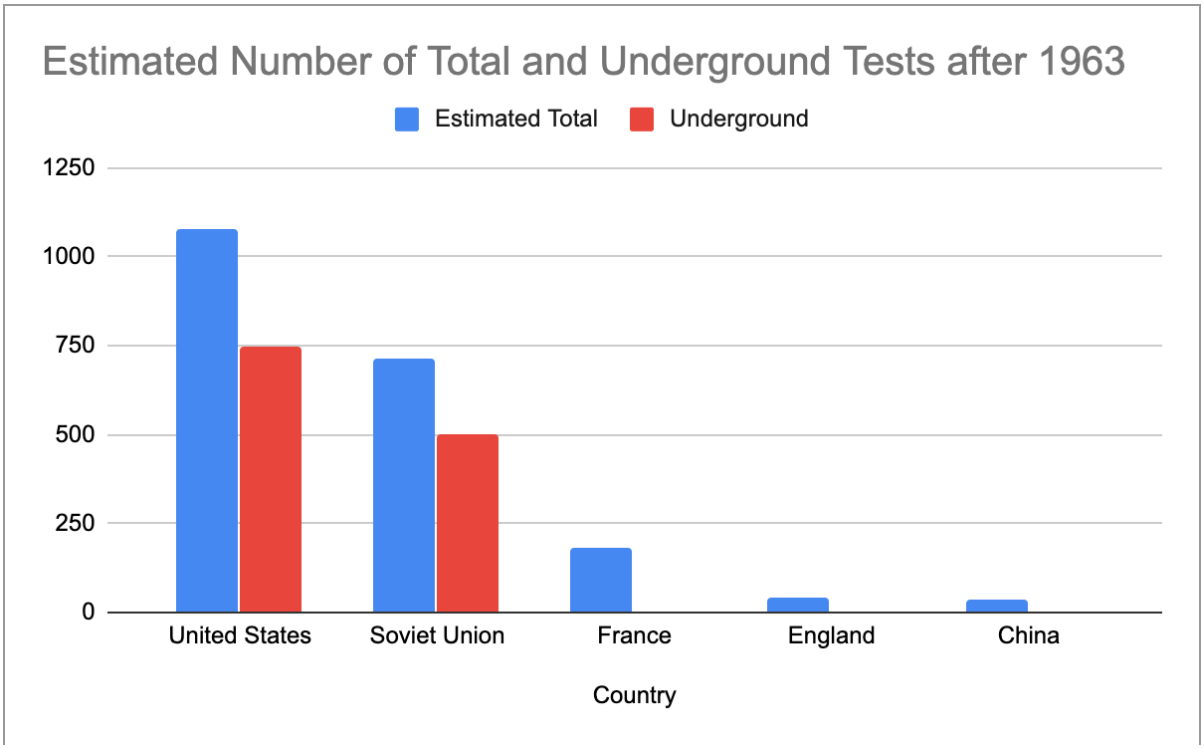


Figure 1. Estimated number of total and underground nuclear tests conducted after signing of 1963 Moscow Treaty. Numbers based on V.N. Mikhaylov's summation of Soviet assessments of open publications and national technical means. [130] Soviet estimations are used throughout paper unless otherwise noted. This choice is not a reflection of the (in)accuracy of any country's data, but for internal consistency.

[130] Mikhaylov, Vikor Nikitovich. *I am a Hawk: Memoirs of Atomic Energy Minister Mikhaylov.* (1996). The Pentland Press Ltd. Hutton Close. Print. pp. 85.

C. TIMELINE OF KEY EVENTS

1946	USSR proposes a ban on atomic weapons to United Nations
1955	USSR proposes a ban on testing, US and Soviet scientists meet at 1st International Conferences on Peaceful Uses of Nuclear Energy
1963	Thanks to efforts by Soviet Union, the US, Great Britain, and the USSR sign the Moscow Treaty/LTBT, banning nuclear testing in space, the atmosphere, and underwater
1974	TTBT signed in Moscow limiting underground test yield to 150 kilotons
1976	PNET signed
1981	NRDC begins *Nuclear Weapons Databook* Series
1983	US begins attempts to dialogue with USSR on TBT verification, FAS scientists accept SAS invitation to discuss arms control in Moscow
1984	Reagan proposes onsite measurements
1985	Soviet Union declares unilateral testing moratorium, Gorbachev is elected; US invites Soviet experts to NTS and proposes technical talks
1986	Gorbachev presents a program for a nuclear free world by 2000; Reagan invites Soviet experts to witness a test and examine CORRTEX. Experts meet in Geneva to discuss testing, Reykjavik Summit.
1987	USSR Minister of Foreign Affairs and US Secretary of State outline procedures for JVE

1988	USSR-US Agreement on JVE signed at 4th American-Soviet Summit Meeting
1989	Supreme Soviet appeals to US Congress “On the Issue of Nuclear Tests Moratorium and on the Termination of Nuclear Tests”
1988-1990	NTT held in Geneva
24 October 1990	Last Soviet test on the Northern Test Site
1992/3	Protocol to the Treaty of 1974 signed establishing verification methods and procedures

D. SELECT GOVERNMENT DOCUMENTS

1. Changes to the RAN Charter - Original

II. Предмет, цели и виды деятельности, основные задачи и функции Академии

11. Предметом деятельности Академии является обеспечение преемственности и координации фундаментальных научных исследований и поисковых научных исследований, проводимых по важнейшим направлениям естественных, технических, медицинских, сельскохозяйственных, общественных и гуманитарных наук, экспертного научного обеспечения деятельности органов государственной власти и научно-методического руководства научной и научно-технической деятельностью научных организаций и образовательных организаций высшего образования.

2. Changes to the RAN Charter- 2019 Addition

1. Пункт 11 изложить в следующей редакции:

"11. Предметом деятельности Академии является обеспечение преемственности и координации:

фундаментальных научных исследований и поисковых научных исследований, проводимых по важнейшим направлениям естественных, технических, медицинских, сельскохозяйственных, общественных и гуманитарных наук;

научных исследований, реализуемых в сфере оборонно-промышленного комплекса в интересах обороны страны и безопасности государства;

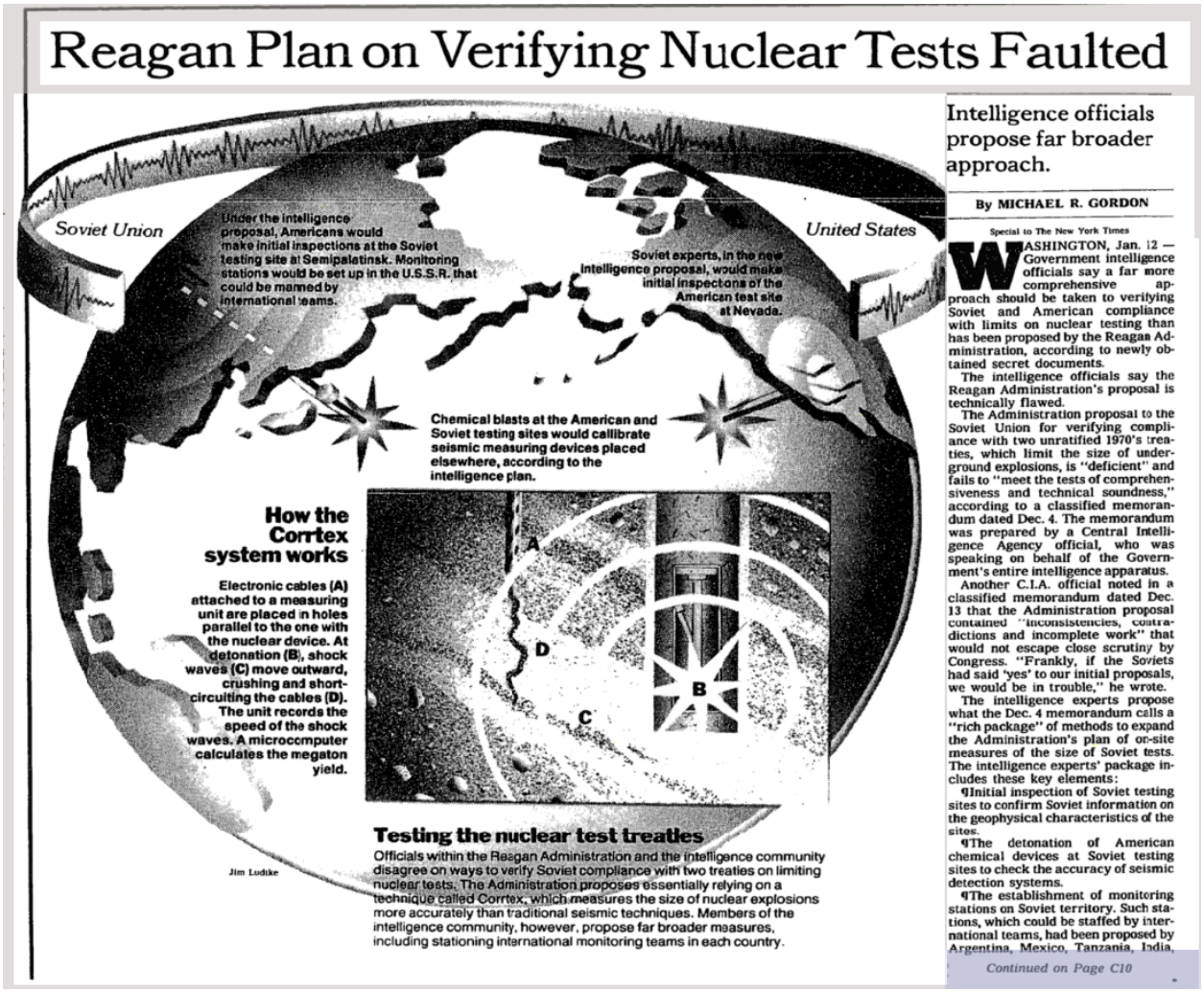
экспертного научного обеспечения деятельности органов государственной власти Российской Федерации;

научно-методического руководства научной и научно-технической деятельностью научных организаций и образовательных организаций высшего образования.".

E. ARCHIVAL PHOTOGRAPHS

Picture 1. Soviet and American Seismologists during initial discussions of monitoring at the Nevada Test Site. (From left to right) Front row: J. Berger, C. Archambault, T. Cochran (interviews for this thesis), O. Stolyarov, N. Tarasov, K. Priestley Back row: S. Daragan, I. Nersesov, J. Brun, E. Sutulov. Institute of Geophysics and planetary physics of the University of California, San Diego, USA, Fall 1986.

Picture 2. American and Soviet Scientists in the Control Room for the JVE. NF-9390-CPNNSA/NSO Nuclear Testing Archive. Nevada Nuclear Security Site, Las Vegas, NV. Accessed: March 2020



Reagan Plan on Verifying Nuclear Tests Faulted

Soviet Union

Under the intelligence proposal, Americans would make initial inspections at the Soviet testing site at Semipalatinsk. Monitoring stations would be set up in the U.S.S.R. that could be manned by international teams.

United States

Soviet experts, in the new intelligence proposal, would make initial inspections of the American test site at Nevada.

Chemical blasts at the American and Soviet testing sites would calibrate seismic measuring devices placed elsewhere, according to the intelligence plan.

How the Corrtex system works

Electronic cables (A) attached to a measuring unit are placed in holes parallel to the one with the nuclear device. At detonation (B), shock waves (C) move outward, crushing and short-circuiting the cables (D). The unit records the speed of the shock waves. A microccmputer calculates the megaton yield.

A
D
B
C

Jim Ludke

Testing the nuclear test treaties

Officials within the Reagan Administration and the intelligence community disagree on ways to verify Soviet compliance with two treaties on limiting nuclear tests. The Administration proposes essentially relying on a technique called Corrtex, which measures the size of nuclear explosions more accurately than traditional seismic techniques. Members of the intelligence community, however, propose far broader measures, including stationing international monitoring teams in each country.

Intelligence officials propose far broader approach.

By MICHAEL R. GORDON

Special to The New York Times

WASHINGTON, Jan. 12 — Government intelligence officials say a far more comprehensive approach should be taken to verifying Soviet and American compliance with limits on nuclear testing than has been proposed by the Reagan Administration, according to newly obtained secret documents.

The intelligence officials say the Reagan Administration's proposal is technically flawed.

The Administration proposal to the Soviet Union for verifying compliance with two unratified 1970's treaties, which limit the size of underground explosions, is "deficient" and fails to "meet the tests of comprehensiveness and technical soundness," according to a classified memorandum dated Dec. 4. The memorandum was prepared by a Central Intelligence Agency official, who was speaking on behalf of the Government's entire intelligence apparatus.

Another C.I.A. official noted in a classified memorandum dated Dec. 13 that the Administration proposal contained "inconsistencies, contradictions and incomplete work" that would not escape close scrutiny by Congress. "Frankly, if the Soviets had said 'yes' to our initial proposals, we would be in trouble," he wrote.

The intelligence experts propose what the Dec. 4 memorandum calls a "rich package" of methods to expand the Administration's plan of on-site measures of the size of Soviet tests. The intelligence experts' package includes these key elements:

¶Initial inspection of Soviet testing sites to confirm Soviet information on the geophysical characteristics of the sites.

¶The detonation of American chemical devices at Soviet testing sites to check the accuracy of seismic detection systems.

¶The establishment of monitoring stations on Soviet territory. Such stations, which could be staffed by international teams, had been proposed by Argentina, Mexico, Tanzania, India,

Continued on Page C10

Picture 3. Description of CORRTEX System. Image by Jim Ludke for Gordon, Michael R. "Reagan Plan on Verifying Nuclear Test Faulted: Intelligence Officials Propose Far Broader Approach." *The New York Times*. January 13, 1987.

XI. REFERENCES

Амрамина, А. А. and Пилипенко В. А. “Советско-американский проект по мониторингу подземных ядерных испытаний: научные, социальные и политические аспекты.” *Вестник ОНЗ РАН,* Том 10. NZ1103. July 2018.

“Совместный эксперимент: ответы на вопросы корреспондента ТАСС руководителя группы советских специалистов, вылетающих на Невадский испытательный полигон.” *Красная звезда.* No. 140 (19627). 18 июня 1988 г. http://elib.biblioatom.ru/text/mihaylov_ya-yastreb_2008/go,76/

Концепция национальной безопасности российской федерации. Утверждена Указом Президента Российской Федерации № 24 от 10.01. 2000 г.

“О Стратегии национальной безопасности Российской Федерации” Указ Президента Российской Федерации от 31.12.2015 г. № 683

“Как менялся порядок выборов президента РАН. Досье.” Без автора. 12 июл. 2017. https://tass.ru/info/4409632

Avrorin, Evgeny N. “Just Like Us”. *Doomed to Cooperate Volume I,* edited by Siegfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. pp. 82.

Barth, Kai-Henrick “Catalysts of Change: Scientists as Transnational Arms Control Advocates in the 1980s” *OSIRIS.* 2006: 21. pg. 182-206.

Basis for Negotiation of Nuclear Test Verification Measures” NSDD 63 (October 28, 1982). Reagan Presidential Library.

Bureau of Arms Control Verification, and Compliance. “Treaty Banning Nuclear Weapons in the Atmosphere, in Outer Space and Under Water” *US Department of State.* https://2009-2017.state.gov/t/avc/trty/199116.htm#treaty

“Chris Paine - Short Bio” *Nuclear Watch.* Web. https://www.nukewatch.org/info/Chris-Paine-Bio.pdf

Chronology of Historical Events and Negotiations Leading to Joint Verification Experiment.” No Date. NV0320159. NNSA/NSO Nuclear Testing Archive. Nevada Nuclear Security Site, Las Vegas, NV. Accessed: March 2020.

Cochran, Thomas B. "Black Sea Experiment only a Start," *Bulletin of Atomic Scientists,* Nov. 1989. pp. 13-16. https://books.google.com/books?id=6AUAAAAAMBAJ&pg=PA12&lpg=PA12#v=onepage&q&f=false

Cochran, Thomas. Personal interview. 01 April 2020.

Cochran, Thomas B. "The Black Sea Experiment." *From Reykjavik to New START: Science Diplomacy for Nuclear Security in the 21st Century,* Washington, DC. January 19, 2011. Conference Paper. Keek Center of the National Academies. Accessed 2020.

Dezhina, Irina, Science and Innovations in Russia in 2018 (September 5, 2019). Russian Economy in 2018. Trends and Outlooks (Issue 40). 2019. Moscow. IEP, pp. 461-484.

D.L., "Senate Considers Testing Treaties," *Arms Control Today.* Vol. 20, No. 7. September 1990. pp. 19.

Establishment of National Security Council Arm Control Verification Committee. NSDD 65 (November 10, 1982). Reagan Presidential Library.

Evernden, J. E., Archambeau, C. B., and Cranswick E. "An Evaluation of Seismic decoupling and underground nuclear test monitoring using high-frequency seismic data." *Reviews of Geophysics*. Vol. 24, Issue 2. May 1986. https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/RG024i002p00143

Hoffman, David. "1983: A Turning Point in the Cold War." Security Index. No. 1 (81), Vol. 3. http://auteurs.harmattan.fr/la-dissuasion-nucleaire/files/2012/02/1983_Turning_Point_of_the_Cold_War4.pdf

General Advisory Committee Report Excerpts," *The Bulletin of Atomic Scientists.* Jan. 1983. pp 32-34. https://books.google.com/books?id=oAYAAAAAMBAJ&printsec=frontcover#v=onepage&q&f=false

Goodnight, Thomas G. "Ronald Reagan's re-formulation of the rhetoric of war: Analysis of the "zero option," "evil empire," and "star wars" addresses." *Quarterly Journal of Speech.* Vol. 72, Issue 4. 1986.

Gordon, Michael R. "Reagan Plan on Verifying Nuclear Test Faulted: Intelligence Officials Propose Far Broader Approach." *The New York Times.* January 13, 1987.

Gordon, Michael R. "Reagan, in a Letter to Gorbachev, asks Technical Talks on A-Tests." *New York Times.* December 25, 1985.

Halverson, Thomas E. "Limited Movement in Nuclear Testing Talks." *Arms Control Today.* Vol. 19. No. 7. September 1989. pp. 30.

James, Jesse. "Soviet Experts Tour U.S. Nuclear Test Site." *Arms Control Today.* Vol. 18, No. 2. March 1988. pp. 25.

Joint Soviet-United States Statement on the Summit Meeting in Geneva. November 21, 1985. Reagan Presidential Library.

Jorgenson, Eric. Personal communication. 07 April 2020.

Krepon, Michael. "Joint Verification Experiments," *Arms Control Wonk.* January 11, 2011. https://www.armscontrolwonk.com/archive/402990/joint-verification-experiments/

Mikhaylov, Vikor Nikitovich. *I am a Hawk: Memoirs of Atomic Energy Minister Mikhaylov.* (1996). The Pentland Press Ltd. Hutton Close. Print. 195 pages.

Norris, Robert S., Cochran, Thomas B., and Paine, Christopher E. "A History of NRDC's Nuclear Activities." NRDC Files. September 8, 2010.

"On making changes to the charter of the federal government budget of the institutes RAS" 25.04.2019 No. 496

Podvig, Pavel. "Did Star Wars Help End the Cold War? Soviet Response to the SDI Program." *Science and Global Security.* Vol. 25, Issue 1. February 2017.

Public Affairs Plan for Joint Verification Experiments. No Date. NV NNSA/NSO Nuclear Testing 0318979. Archive. Nevada Nuclear Security Site, Las Vegas, NV. Accessed: March 2020.

Public Affairs Plan for Soviet Orientation Visit to Nevada Test Site (Draft). January 6, 1988. NV0319254. NNSA/NSO Nuclear Testing Archive. Nevada Nuclear Security Site, Las Vegas, NV. Accessed: March 2020.

Reagan, Ronald. "Address to the National Association of Evangelicals ("Evil Empire Speech")". *Voices of Democracy: The U.S. Oratory Project*. University of Maryland, College Park. March 8, 1983.

Reagan, Ronald. "Address to the Nation and Other Countries on United States-Soviet Relations." January 16, 1984. Reagan presidential library. https://www.reaganlibrary.gov/research/speeches/11684a

Reagan, Ronald. Diary Entry. Monday Oct 10, 1983. https://www.reaganfoundation.org/ronald-reagan/white-house-diaries/diary-entry-10101983/

Robinson, C. Paul. "The Joint Verification Experiment and Nuclear Testing Talks: Important Precursors to the US-Russian Lab-to-Lab Programs." *Doomed to Cooperate Volume I,* edited by Sigfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. pp. 84-116.

Schrag, Philip G. *Listening for the Bomb: A Study in Nuclear Arms Verification Policy*. New York, Routledge, 2018.

"The Intermediate Range Nuclear Forces (INF) Treaty at a Glance" *Arms Control Association Briefs.* August 2019.

"US-Russian Lab-to-Lab Nuclear Cooperation Timeline" *Doomed to Cooperate Volume I,* edited by Sigfried Hecker, Bathtub Row Press, Los Alamos, NM, 2016. pp. xiii-xviii.

U.S. Nuclear Testing Limitations Policy. National Security Decision Directive Number 51 (August 10, 1982).

"United States Nuclear Tests: July 1945 through September 1992." DOE/NV--209-REV 16. NNSA/NSO Nuclear Testing Archive.. Nevada Nuclear Security Site, Las Vegas, NV. Online. https://www.nnss.gov/docs/docs_LibraryPublications/DOE_NV-209_Rev16.pdf

Von Hippel, Frank. “FAS’s Contribution to Ending the Cold War Nuclear Arms Race” *Federation of American Scientists Public Interest Report.* 2016. https://fas.org/wp-content/uploads/2016/05/8_FvH_FAS-in-the-1980s_finalWEB.pdf